IEICE (the Institute of Electronics, Information and Communication Engineers) General conference 2003

(２００３年電子情報通信学会総合大会)

A Study on Complementary Code Keying Demodulation in 802.11b Wireless LAN

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1. Preface

        There is the 802.11b model as an example of the high-speed wireless LAN used in the indoor environment. This uses CCK (Complementary Code Keying) as a modulation scheme by which to realize the transmission rate of 5.5 Mbps and 11 Mbps in the 2.4 GHz band. In this paper, we evaluate the characteristics of a modulation scheme of CCK in the specifications at a receiving side, using the maximum likelihood estimation method, under the additive noise environment and fading environment.
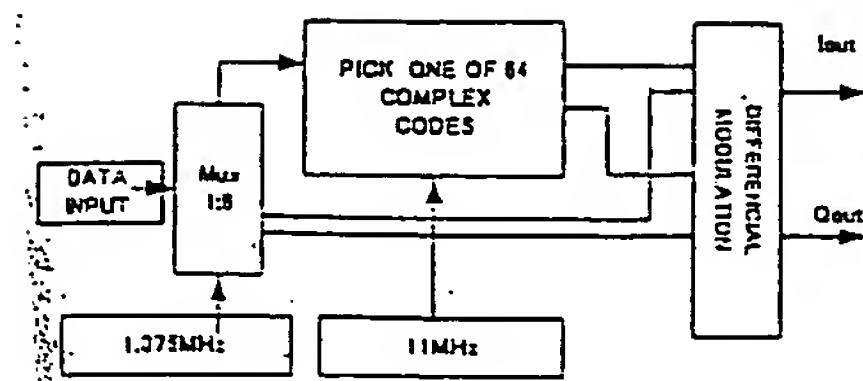
2. Structure of 802.11b

FIG. 1: CCK modulator at 11 Mbps

The CCK, which is a modulation scheme realizing max. 11 Mbps in IEEE 802.11b, is configured as shown in FIG. 1. The input data are serial-parallel converted per 8 bits, and the 2 bits uses the DQPSK modulation method and the 6-bit information is CCK modulated so as to achieve high speed [1].

3. CCK (Complementary Code Keying)

If, in the CCK modulation, d_i, $i \in \{0,1,2,3,4,5,6,7\}$ is 8-bit information, these will be modulated into four phase values φ_i, $i \in \{1,2,3,4\}$ by performing DQPSK modulation on d_0 and d_1 (determination of φ_1) and performing QPSK modulation (determination of φ_2, φ_3 and φ_4) on d_2 to d_7.

$$\mathbf{c} = \{e^{j(\varphi_1 + \varphi_2 + \varphi_3 + \varphi_4)}\}, e^{j(\varphi_1 + \varphi_3 + \varphi_4)}, e^{j(\varphi_1 + \varphi_2 + \varphi_4)}, -e^{j(\varphi_1 + \varphi_4)},$$

$$e^{j(\varphi_1 + \varphi_2 + \varphi_3)}, e^{j(\varphi_1 + \varphi_3)}, -e^{j(\varphi_1 + \varphi_2)}, e^{j(\varphi_1)}\}$$

$$= e^{j\varphi_1}\{e^{j(\varphi_2 + \varphi_3 + \varphi_4)}\}, e^{j(\varphi_3 + \varphi_4)}, e^{j(\varphi_2 + \varphi_4)}, -e^{j(\varphi_4)}, e^{j(\varphi_2 + \varphi_3)},$$

$$e^{j(\varphi_3)}, -e^{j(\varphi_2)}, 1\}$$

$$= e^{j\varphi_1} \widetilde{c} \qquad \qquad \text{--- (1)}$$

By substituting φ_j into Equation (1), a 8-bit code is created so as to be transmitted [2]. ($\tilde{c}$ is a code constituted by 6 bits)

4. CCK Decoding

(1) AWGN (Additive White Gaussian Noise) model

$$\mathbf{r}=\mathbf{c}^{(k)}+\mathbf{n} \qquad\qquad\qquad \text{--- (2)}$$

If a received signal in the additive noise environment is given by Equation (2), a code $\hat{c}^{(k')}$ giving the most likelihood will be obtained using Equation (3) in order to estimate the optimum transmission code. ($\mathbf{n}$: Gaussian Noise, k=1, 2, … 256)

$$\hat{c}^{(k')}=\arg \underset{c^{(k)}}{\text{Max}}\, \text{Re}(\mathbf{r}^{\dagger}\mathbf{c}^{(k)}) \qquad\qquad \text{--- (3)}$$

(2) Fading model

$$\mathbf{r}=A\mathbf{c}^{(k)}+\mathbf{n} \quad (A : \text{fading coefficient}) \qquad \text{--- (4)}$$

When a received signal in a fading environment is given by Equation (4), the most likelihood code is obtained from the condition (5). It is assumed that the fading coefficient A is known in the receiving side.

$$\hat{c}^{(k')}=\arg \underset{c^{(k)}}{\text{Max}}\, \text{Re}(A\mathbf{c}^{(k)}) \qquad\qquad \text{--- (5)}$$

5. Characteristic evaluation by simulation

A comparison is made, in the evaluation of bit error rate under the AWGN environment and the fading environment,

between a case where, in the 8-bit information, 6-bit code is estimated from $Max|\mathbf{r}^\dagger \tilde{\mathbf{c}}|$ and the remaining 2 bits are obtained from DQPSK and a case where the entire 8-bit code **c** is estimated from the code correlation. The result of simulation under the AWGN environment is shown in FIG. 2 and the result under the fading environment is shown in FIG. 3.
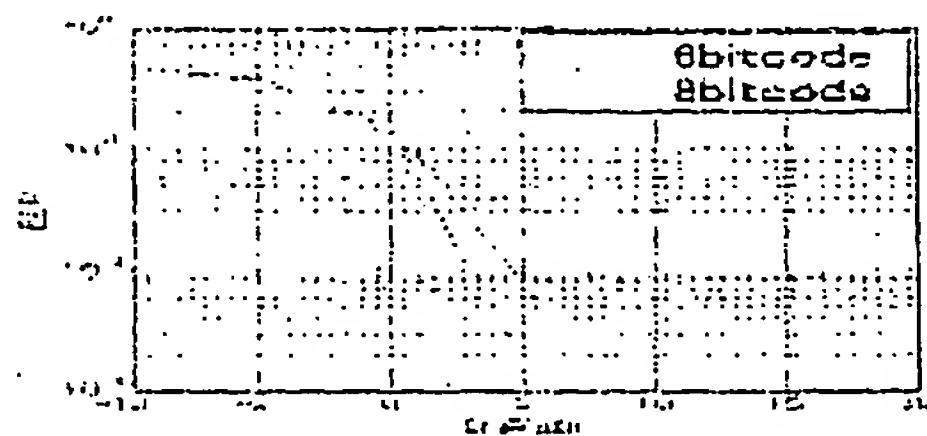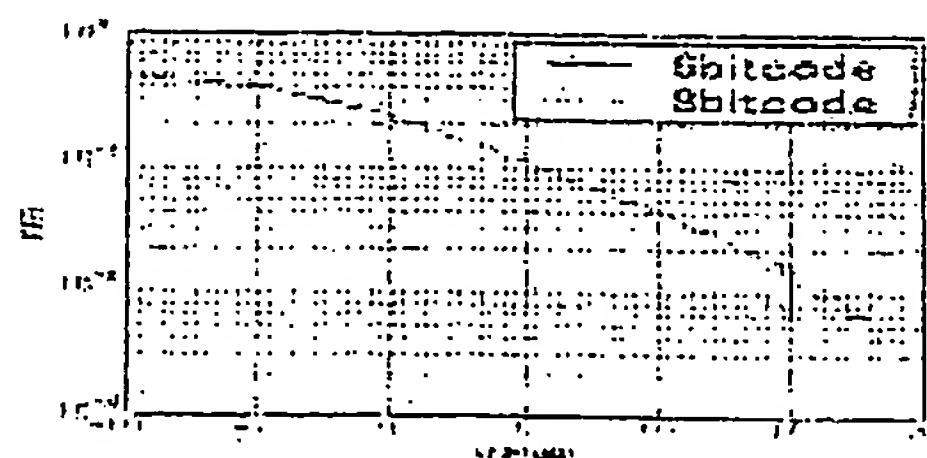
FIG. 2: Error rate characteristic in AWGN

FIG. 3: Error rate characteristic in the fading environment

6. Conclusion

Since not much difference was observed in BER between the estimation result by the 6-bit code correlation and the DQPSK demodulation and that by the 8-bit correlation, the processing by the 6-bit code is found to be effective also. Furthermore, an investigation on the error rate

characteristics in a delayed wave environment is also scheduled.

REFERENCES

[1] Bob O'Hara and Al Petrick, "IEEE802.11 Handbook; A Designer's Comparison" p154, IEEE Press 1999

[2] IEEE Std 802.11b-1999 (Supplement to ANSI/IEEE Std 802.11, 1999 Edition)